engine invented and developed by the late Mr. Willans, or of, what is perhaps of more importance, the influence of his investigations into the actual performance of steam-engines upon the thermal design of prime movers generally. His happy inspiration to weigh the condensate from his engines at different loads and to plot the result, led to the discovery of the Willans " straight-line law ", which has had far-reaching effects and has given the designer a qualitative test of performance which had been lacking. By thus giving purchasers a ready means of checking guarantees, the performance, not only of steam-engines but also of turbines, has steadily improved under the incentive of competition. Freak designs, the product of misapplied ingenuity, were thus quickly suppressed, and the rapid development of the electrical industry greatly promoted.

The Willans engine possessed many novel mechanical features, evolved to meet the combination of high rotative speed and constant thrust, but these are now mainly of historical interest, as the engine is no longer manufactured.

Each crank was driven by a complete engine, so that the consumption per indicated horse-power was for an engine of only one-third the output in the case of a three-crank engine. The multiplicity of rubbing surfaces (for in a three-crank triple engine there were twelve pistons, including one " air buffer " and nine piston valves) gave a low mechanical efficiency, and these features caused the steam consumption, when reckoned on the basis of brake horse-power, to be much higher than that of the plain double-acting triple-expansion engine with three cylinders only.

There have been many varieties of high-speed engines, but the only one surviving of importance is that developed by Messrs. Belliss & Morcom, of Birmingham, and which alone will be described in these pages. It must be understood, of course, that there are other makes of this type which have each special features of interest, examples of which will be given.

General.—High-speed engines are made in standard sizes, and because of their intimate relation with the electrical

industry, the rotative speeds which have been fixed for electrical generators have been largely adopted for the engines, so that this fixed condition is the starting-point in design. The power of a high-speed engine is often given in brake horse-power and sometimes in kilowatts. The indicated horse-power is never stated. It is a figure interesting principally to the manufacturers in design.

The relations usually adopted of the powers and speeds is given in the table:

Kw.	25	So	75-100	150-200	250-400	500-750	IOOO
B.H.P.	38	75	112-145	220-290	365-570	720-1000	1450
Revs.	650	575-600	Soo-525	428-500	375	300	250

In the case of alternators, the frequency is, of course, the determining factor with regard to speed.